Al-Sadar	956,991	Table A-2
Admiyah	513,877	Table A-2
Rusafa	191,136	Table A-2
Karada	207,760	Table A-2
Baghdad Al-Gadeda	674,794	Table A-2
Sub Total	**2,544,558**	**Table A-3**
TOTAL	**4,320,956**	**Table A-3**

Source:Central Administration of Census, 1997 Census District Information.

8. Population Forecast Methodology

Population forecasts are the main factor influencing long term planning for water supply projects. Population forecasting is based on historic growth trends being in turn influenced y future economic and governmental conditions. The historic annual population growth of the entire country of Iraq and the Governorate of Baghdad is as follows:

Time Period	Iraq Country wide	Baghdad Governorate
1977-1987	**3.15%**	**'1.88%**
1987-1997	**3.12%**	**3.48%**

The percent annual growth rate for Iraq of 3% remained fairly constant from 1977 to 1987 and 1987 to 1999, while the Baghdad Governorate population substantially increased during the 1987 to 1997 time period. Sanctions employed during the Oil-For-Food Program caused major economic hardship among the populace. Inward migration to the governorate was no doubt based upon job creation and economic forces.

9. BWA Current and Future Customers

As stated above, the BWA has the responsibility to serve customers within the boundaries of the Baghdad Mayoralty. For the purpose of this analysis, it is assumed that 100 % of the Baghdad Mayoralty is served by the BWSA. To determine an estimate of the year 2004 customer base, the 1997 census data was projected using an annual population growth of 2.99 %. Table 4 summarizes the projected populations for the Mayoralty. Tables A-1, A-2, and A-3 (see Attachment A) present the detailed population projections by individual census tract.

Table 4
1997 Census Data and Projected Populations Baghdad Mayoralty

District	1997 Populatio	2004 Populati	2010 Populatio	2025 Populatio
Kadhimyah	492,108	604,801	721,922	1,122,990
Karkh	177,736	218,438	260,739	405,594
Rashid	755,181	928,117	1,107,851	1,723,323
Mansour	351,373	431.837	515,464	801,833
Sub-total	**1,776,398**	**2,183,193**	**2,605,976**	**4,053,740**
Al-Sadar	956,991	1,176,142	1,403,906	2,183,853
Admiyah	513,877	631,555	753,858	1,172,667
Rusafa	191,136	233,195	276,908	426,595
Karada	207,760	255,337	304,784	474,108
Baghdad Al-Gadeda	674,794	829,322	989,923	1,539,880
Sub-total	**2,544,558**	**3,125,551**	**3,729,378**	**5,797,104**
TOTAL	**4,320,956**	**5,308,744**	**6,335,353**	**9,850,844**

Source : Central Administration of Census, 1997 Census District Information.

There are three population centers or sections within the governorate, but outside the mayoralty which are Currently served by BWA.

Table 5-A

dISTRICT	1997 populatio n	2004 population	2010 population	2025 populatio n
Al- Rasafa				
AL –Nasser Wal-Salam Section	125,310	154,006	183,830	285,957
Subtotal	125,310	154,006	183,830	285,957

Al-Karkh				
Al-Taji Section	106,556	130,957	156,318	243,161
Al-Rashid section	72,871	89,558	106,902	166,292
Subtotal	179,427	220,515	263,220	409,4 53
TOTAL	**304,737**	**374,521**	**447050**	**695410**

TOTAL POPULATION	**4,625,69 3**	**5,683,265**	**6782403**	**105462 54**

Table 5-B

	Population 1997	Population 2004	Population 2010	Population 2017
Al-Karkh/Daily commuters	80,000	98,320	117,360	182,560
Al-Rasafa/	120,000	147,480	176,040	273.840
TOTAL	**200,000**	**245,800**	**293400**	**456400**
Total population	**4,825,693**	**5,929,065**	**7,075,803**	**11,002,654**

Table 6 provides the estimates of total customers served by the BWSA which were obtained by adding the corresponding projections in Tables 4 and 5A&B.

Table 6

Estimates of Total BSWA Customers

Year	Karkh	Rasafa	Total
2004	2,502,028	3,427,037	5,929,065
2010	3,170,386	4,089,248	7,075,803
2025	4,645,753	6,356,901	1 1,002,654

10. Current and Future Baghdad Water Supply Authority Water Demand

Population projections were used as input data for development of the water demand figures to service all customers of the Baghdad Water Supply Authority (BWSA) for the periods of 2004,2010,2025.

Based on per capita usage and customer projections, the BWSA requires 3,203 million liters per day (MLD) on an average daily basis in 2004. This demand is expected to increase to approximately 3,823 MLD in 2010, and to 5,945 MLD in 2025.

10.1 Production and Consumption Metering

The delivery of water and water consumption in the Mayoralty of Baghdad are estimated rather than metered. Water treatment plant flow meters are generally out of order and only 10% of the estimated 567,551 service connections are equipped with water meters. Because of the lack of metering at both production and consumption points, it is only possible to obtain estimates for production and consumption.

'Table1-gives a--breakdown/of Categories of Users .connected to the water distribution system for the year 2000 as well as the number of metered service connections for each category.

Table 1 Baghdad Mayoralty Service Connections - Year 2000

Consumer Category	Service Connections	%	Metered	Unmetered
Domestic	376,280	66%	48,219	328.061
Industrial and Commercial	53,474	9%	10.469	43,005
Government	121,899	21%	0	121,899
Public (Places of worship & others)	15.898	3%	0	15,898
Total Service connections	567.551	100%	10%	90%

Source: Assessment Project of the Water and Sanitation Sector Iraq, Safege — International department. Sponsored by UNICEF, January 2003. Table 2-24.

About 20% of the industrial/commercial connections are metered while only 13% of the domestic connections are metered

10.2 Water Usage

In 1984, Binnie & Partners (B&P) was instrumental in developing a Baghdad Master Plan for the BWSA. A major portion of the planned water distribution pipeline system was constructed in the mid to late 1980s. As a basis of the master plan, B&P developed per capita water use projections.

- **Actual Water quantity supplied per capita/day:**

In 1987	**310 l/day.**
In 1997	**221 l/day.**
In 2002	**150 l/day.**
1.East bank of the Tigris river	**115 l/day.**
2.West bank of the Tigris river	**170 l/day.**

In 1984, BWA adopted 500 l/c/d for all designs nearing completion or being commissioned. The only exceptions were Taji and Abu Ghraib which were designed based on 400 l/c/d. Because the Baghdad Mayoralty is heavily agricultural, ejections for per capita water usage were developed with industrial/commercial, administrative and unaccounted-for-water included in the overall estimate.

Table 3-is a comparison of per capita breakdowns by specific consumer category developed in the B&P and Safege reports. Both consultants adopted the 500 l/c/d figure for the mayoralty while the B&P Report also proposed a 400 l/c/d figure for Baghdad suburban areas based on a slightly different consumer category breakdown rationale.

Table 3 Year 2000 Consumer Category Breakdown
Per Capita Water Demand
(Liters per capita per day)

Consumer Category	Baghdad City1	Suburban Areas1	Baghdad City2
Domestic	340	275	330
Ad ministrative	35	80	55
industrial/commercial	40	30	40
Net allocation	415 85 (20%)	335	425
Losses (UFW)(%)		65	75 (17.6%)
Per Capita Projection	500	400	500

Integration Study Review. Baghdad Treated Water Supply System. Final Report Binnie & Partners London. November 1984, Table 2.1.
Assessment Project of the Water and Sanitation Sector Iraq. Safege – International Department, Sponsored by UNICEF", January 2003, Table 2-24.

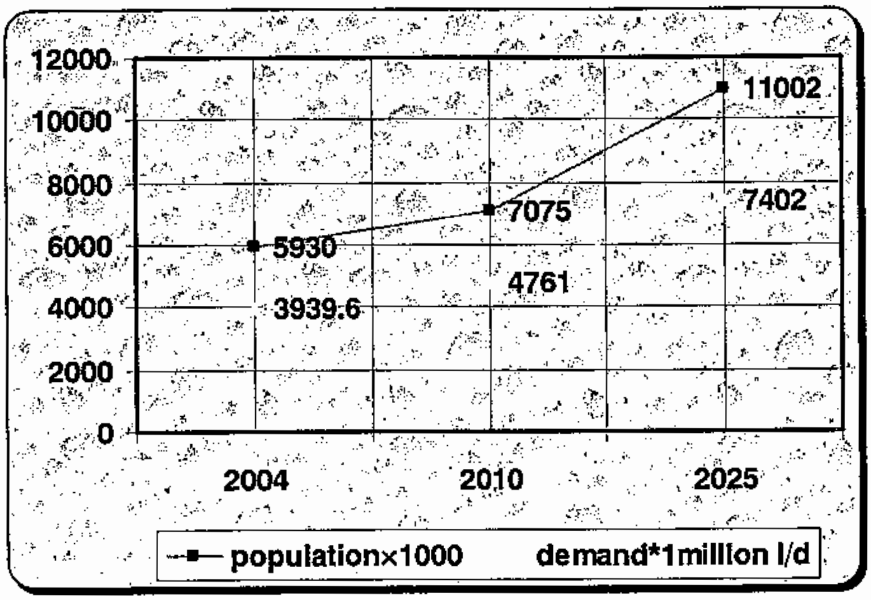
Average demand according to population tables 4- 5A- 5B

Dis	2004 pop	2004 demandx 1million	2010 pop	2010 demandx1 million	2025 pop	2025 demandx 1million
R+K	5308744	2654	6335354	3168	9850844	4925
AL-salam	154006	62	183830	74	285957	114

Daily commuter*	147480	6	176040	7	273840	11
Taji	130957	52	156318	63	243161	97
Rashid	89558	36	106902	43	166292	67
Daily commuter	98320	4	117360	47	182560	73
Total	5930000	2814	7075804	3401	11002654	5287
ave.*1.4		3940		4761		7402

*: commercial consumption 40 l/d/c

Years	2004	2010	2025
population×1000	5930	7075	11002
Demand*1million l/d	3939.6	4761	7402



11. INFORMATION ABOUT WATER SUPPLY IN BAGHDAD

HRER ARE SOME INFORMATION ABOUT WATER SUPPLY AT BAGHDAD CITY:

- **Design capacities of WTPs in Baghdad is 2774000 m3.**
- **Actual production is 2061000 m3.**
- **Total length of distribution and trunks 8000 l.m.**
- **Pipes range 75mm to 2300mm .**

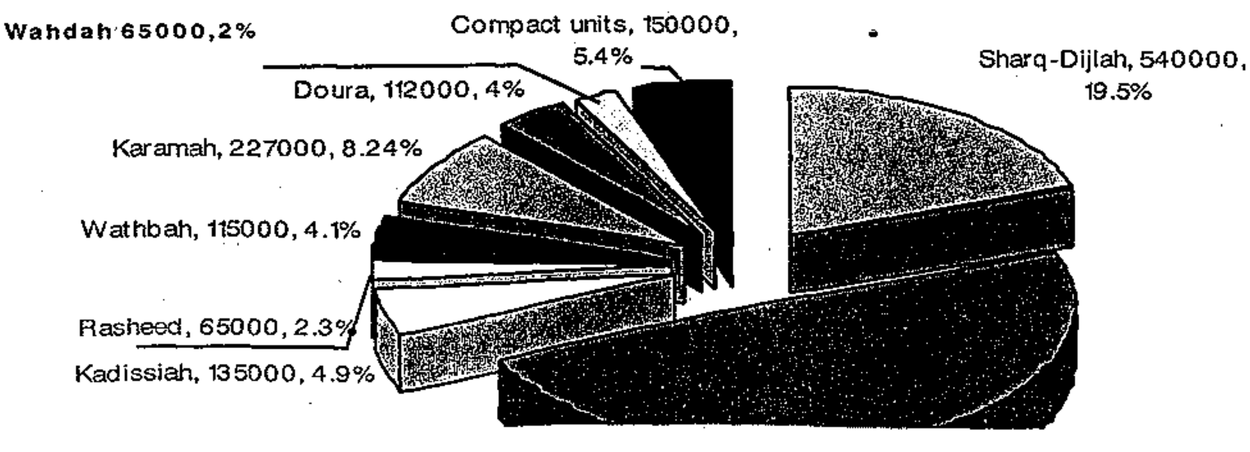
- Number of costumers are 567,550.
- Uncounted for water (UFW) in networks is 55%.
- Average annual daily demand (AADD)500 l/capita/day
- Baghdad's primary and secondary distribution network consists of 12.500 km

12. WATER TREATMENT PLANTS IN BAGHDAD

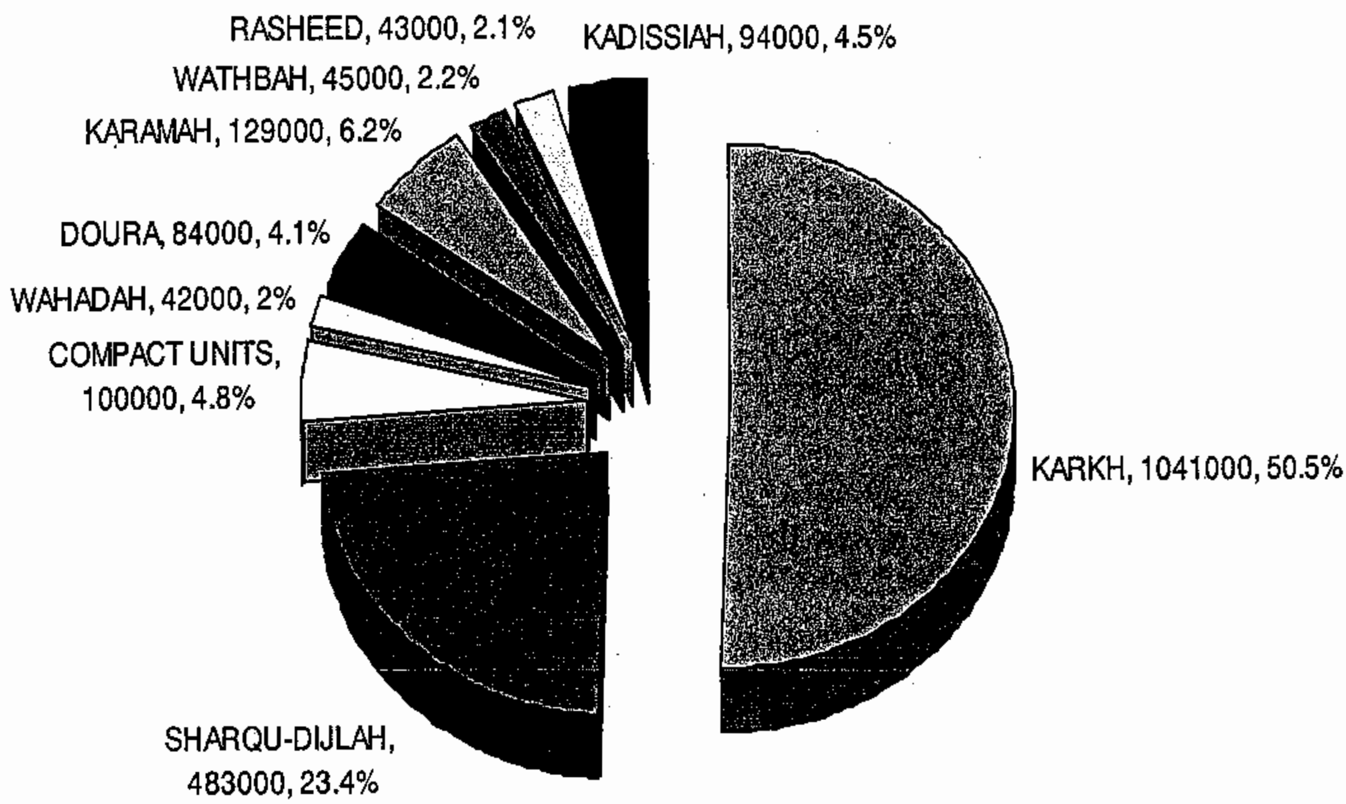
The Fig. below show the Baghdad water treatment plant design production which is equal to 2774000 M^3/day

BAGHDAD WTPs DESIGNED PRODUCTION IN M3/D

TOTAL CAPACITY PRODUCTION 2774000 M3/DAY



ACTUAL PRODUCTION OF WTPs IN BAGHDAD YEAR 2004
TOTAL ACTUAL PRODUCTION 2061000 M3/DAY



13. BWA Plans and Requirement :

In order to improve the Water Supply Sector at Baghdad City and to decrease the shortage for potable water, our plan is to do the fallowing:

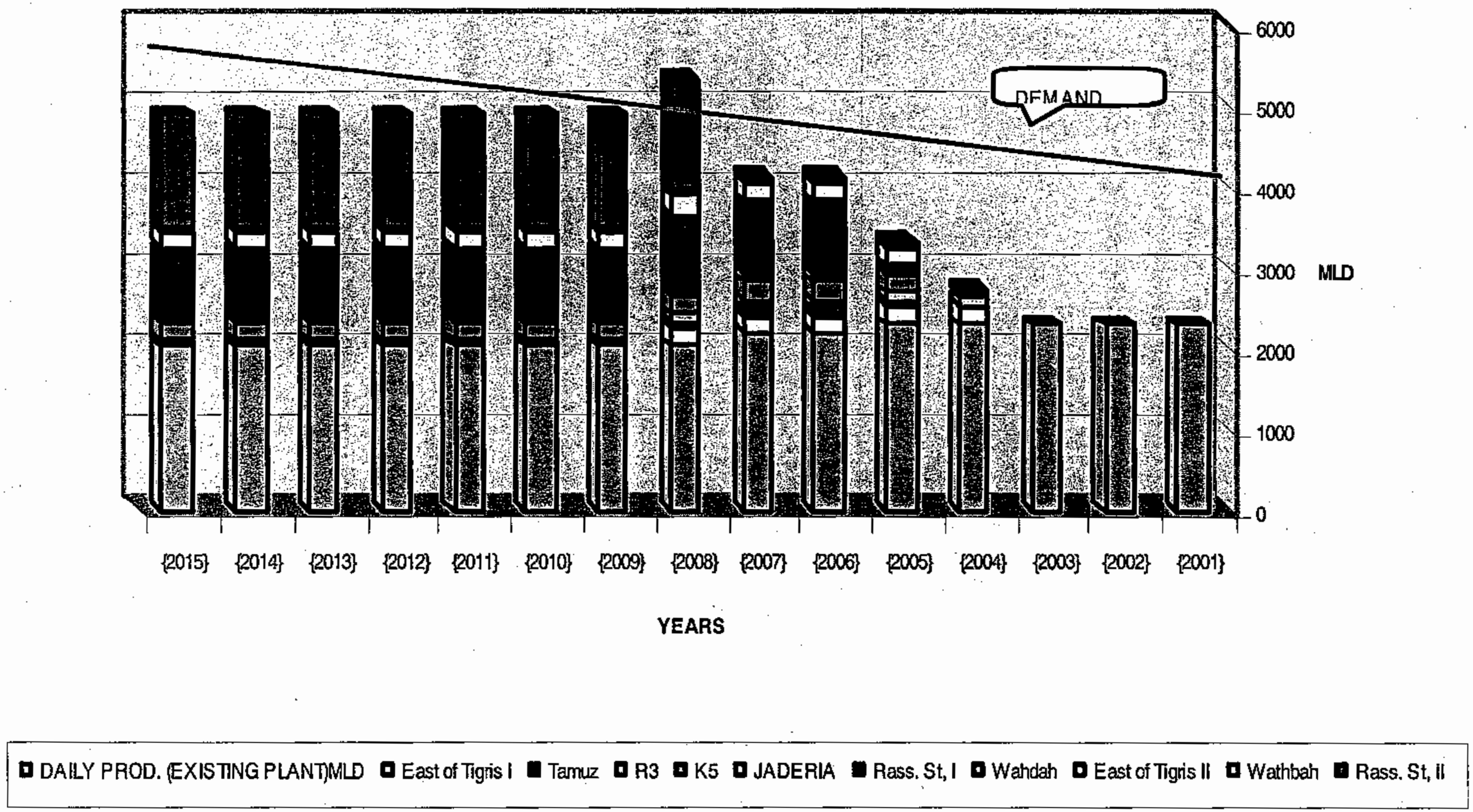
1. **Rehabilitation and upgrading of existing WTPs: This Operation may take one year and halve in order to increase the production capacity for the existing water treatment plants.**
2. **Construction of Ten WTPs/ Which is :**
   - **Shark Dujla 1st Ext.**
   - **Shark Dujla 2nd Ext.**
   - **Sadder WTP (R3)**
   - **Wathbah WTP**
   - **Tamuze WTP**
   - **Wahda WTP**
   - **Jadiria WTP**
   - **Rasheed WTP**
   - **Kadhmia WTP**
   - **Rasafa WTP First Stage & Second Stage**

3. **Construction of Sixteen Earth reservoirs (10 at Rasafa side and six at Karkh side) which is part of Rasafa project.**

4. **Laying of 100 Km of large diameter pipes.**

5. **Renewal of 4200 Km of small diameter pipes with 350,000 house connections.**
6. **Establishment of new water supply management system.**
7. **Establishment of water master plan.**

BAGHDAD CITY - POTABLE WATER DEMAND AND PRODUCTION FOR YEAR 2015



14. FUNDS REQUIRED:

WATER TREATMENT PLANTS	US$ 1600000000
GROUND RESERVOIRS	US$ 750000000
REHABILITATION OF WTPs	US$ 100000000
LAYING LARGE PIPES	US$ 200000000
LAYING SMALL PIPES AND HOUSE CONNECTIONS	US$ 250000000
NEW WATER SUPPLY MANEGMENT SYSTEM	US$ 15000000
GRANT TOTAL	**US$ 2915000000**

15. Supplied water prices:

Prices for supplied water		
category	Consumption / month (X)	Prices (I.D) (1$US=1500I.D)
I	(X) =30	2
II	30<(x)=60	5
III	60<(x)=90	7.5
IV	(x)>90	20
commercial	unlimited	30

16. Produced water costs:

1. Due to missing of proper water supply management system in Baghdad water authority, the tariff structure and the expenditures do not stand for actual produced water cost and the incomings of supplied water.
2. The Authority starts to have a system for computing all expenses and revenues for produced water and supplied water in order to establish the cost of produced water and to evaluate financially the performance of the Authority.

17. Unaccounted-for-Water(UFW)

Water loss in distribution systems, unaccounted-for-water (UFW), is a critical problem facing many water operators. Losses as high as 35-40% are not un common) The situation in Iraq is exacerbated by the country's political and economic situation. Sanctions employed during the Food-For oil program slowed down importation of water system spare parts, and the hiring and ling of BWSA staff. The water distribution system has been in a state of continuous deterioration for the past 10 years- With the most recent violence, BWSA reported that after April 9, 2003 its central warehouse had been completely vandalized .No system rehabilitation was conducted in 2003.

17.1 Historic Perspective:

As outlined above, B&P documented a per capita water

Consumption in Baghdad of 230 l/c/d for 1984 and projected a value of 500 l/c/d for the 2000 (see Table 2). As indicated in Table 3, the Baghdad City UFW component developed by B&P was reported to be 20%. Binnie & Partners presented neither a 1984 UFW estimate nor a rationale for the 20% UFW reported value in its report.

In Table 3, Safege estimated a UFW at 17.6%, which appears to conflict with the city Wide estimates discussed

In 2003, the Safege Report presented city wide estimates of UFW for the y London.ear 2000 using two methods — one a gross overview of water production and usage value, and the second estimate developed at a sub-district level. BWSA reported 2000 water production at 53,796,000 m3 month and estimated water billed at 27,617,000 m3/month, or 50% . UNICEF conducted a network efficiency survey at a sub-district level in the Mayoralty of Baghdad which resulted in an estimate of 40% Thus , UFW city wide estimates range between 40% and 50% for the mayoralty in 2000.

UFW Sources — Water losses in the Baghdad water distribution system are attributed to the following:

• Because 63% of the pipe network is old or very old and constructed of asbestos cement, cast iron, or steel, the network experiences frequent ruptures and leaks. Old is defined as 20 to 35 years old, very old is greater than 35 years or more .

• System maintenance is characterized by emergency repairs rather than programmed maintenance.

• Water production is insufficient which promotes illegal connections.

*Service connections are often constructed of poor-quality plastic without any use of saddles, clamps, or stop cocks, both of which are the source of leaks.

UFW Reduction Program — "No water supply development plan can be effective without efforts to dramatically reduce losses." The safege Report recommended a UFW pilot program to address three study areas: the Mayoralty of Baghdad, one governorate capital city, and one city in the Autonomous ion of Northern Iraq.

Implementation of the pilot area program was to be governed by a specific procedure involving the setting up of teams dedicated to UFW reduction. These teams were to comprise a number of units, each with a specific function. The different units will be complementary, and the program was to be based on their combined output.

The functional units would be as follows:

- Hydraulic Unit implement computer based hydraulic model and set up meters for calibrating the model
- GIS Unit produce maps from data furnished by field surveys
- MIS Unit collect operational and billing data for inclusion in the MIS database
- Leak Detection Unit monitor UFW and other actions in coordination with the Pipe Repair Unit

Pipe Repair Unit Consumer SurveyUnit

Replace service lines or pipe segments identified as leaking

Address non-physical losses associated with illegal, connetion, under metering, etc .this effort be governed by the degree of metering adopted across each pilot area.

All of the functional units of the comprehensive UFW Reduction Program are integral to BWA's management ability to identify problems, assess corrective action, and monitor UFW reduction over time. This pilot program should definitely have a place in the current BWSA's Master Plan.

Reservoir Service Areas

The Master Plan developed for the BWSA by B&P in 1984 provided several water supply schemes intended to increase production capacity and facilitate the transfer of water from north to south and from east to west. The Master Plan also proposed restructuring of the network system which entailed splitting the network into 20 separate pressure zones or reservoir service areas (RSA). Each RSA would contain a reservoir and booster station. The reservoir would be supplied by gravity trunk lines interconnected throughout the entire city. The booster stations would be used to supply adequate pressure to each of the individual RSAs. There would be no interconnections between the individual distribution systems in each RSA. Figure 1 shows the boundary limits of the mayoralty as well as the individual RSAs; namely, R1, R2, K1, K2. Etc.

Most of the treatment and storage works proposed in the Master Plan were either postponed or never implemented. Among the projects postponed was construction of a large treatment plant at Rasafa designed to solve the problem of water shortage on the east side of the city. Only eight reservoirs were constructed but most of the proposed boosting stations were never implemented.

This situation resulted in direct pumping from the water treatment plants into the distribution networks which generated high pressure variations and led to a non-optimized mode of operation. BWSA personnel are required to throttle valves at pumping facilities and inside RSAs to equalize pressure throughout the system.

BWSA Current and Future Water Demand

The BWSA service area within the Mayoralty of Baghdad is divided into Al-Karkh n the west side of the .Tigris River and Al-Rasafa on the east side of the river. Tables A-1 and A-2 (see Attachment A) present water demand projection divided in to Al-Karkh and Al-Rasafa, respectively. Table A-1 summarizes the individual census tracts, corresponding population projections, and water demand for each RSA within ie Al-Karkh area. The water demand for each planning period was determined using

the 500 l/c/d standard water demands. Unfortunately, there was no disaggregated water use data available to either vary the per capita usage over time or vary its value by RSA. Considering the high UFW component which has been discussed, it is recommended that funding be made available to initiate a comprehensive pilot UFW deduction Program. The per capita demand figures should be revisited in the future and reduced depending on the success of the

17.2 UFW Reduction Program.

Table A-2 summarizes the individual census tracts, corresponding population projections, and Water demand-for* -each' RSA within the Al-Rasafa area,

Table 4 summarizes the projected water demand for the mayoralty which has its basis in Tables A-1 and A-2 of Appendix A. Based on per capita usage and customer projections, the BWSA requires 2,654 MLD on an average daily basis in 2004. This demand is expected to increase to approximately 3,168 MLO in 2010, and to 4,925 MLD in 2025 to meet the needs of the mayoralty.

There are eight population centers or sections within the governorate, but outside the mayoralty which are currently served by the BWSA. Table 5 presents these population centers along with projected populations and water demand using the standard water demand of 500 1/c/d. The BWSA requires 549 MLD on an average daily basis in 2004 to provide water for these 8 population centers. This demand will increase to 655 MLD in 2010 and .1, 019 MLD in 2025. This demand represents approximately 21% of the mayoralty demand.

Table 6 provides the total estimates of water demand obtained by adding the corresponding projections in Tables 4 and 5. Based on per capita usage and customer projections, the BWSA requires 3,203 MLD on an average daily basis in 2004. This demand will increase to approximately 3,823 MLD in 2010 and to 5,945 MLD in 2025.

There is two issues that required further explanation from BWSA. The first is whether the eight population centers identified as being outside the mayoralty represent 89% of the governorate population (less the mayoralty). The second issue is whether compact units (CU) are the primary source of treated water for the eight areas outside the mayoralty or have distribution lines been extended into some or all of these areas. Depending on how these issues are resolved, there may be an impact on the projected water demand figures.

Data from usaid report dated nov- 2004

Growth Estimation of Baghdad Governorate				Water Supply Forcast of Baghdad Governorate							
				1	2	3	4	5	6	7	8
Year	Refugees	Growth Rate [%]	Populatino	Need of water consumption (m3/d/c) (Iraqi Standard)	UFW (%)	Treated Water production TOTAL m3/d	water supply w/out UFW m3/d	Need of supplied drinking water with reduced UFW (%) * column 2 m3/d	Need of supplied drinking water at UFW of 25% m3/d	Legal household connections (%)	water consumption at continuous 70% UFW
2003	n/e	n/e	1000000	0.38	70%	250000	0.250	1266000	506000	[illegible]	1266000
2004	100000	4.0%	1140000	0.37	68%	277000	0.243	1318000	562000	70%	1406000
2005	100000	3.5%	1279000	0.36	63%		0.000	1245000	614000	75%	1535000
2006	100000	3.6%	1425000	0.35	58%		0.000	1188000	665000	80%	1663000
2007	0	3.7%	1478000	0.34	53%		0.000	1069000	670000	85%	1675000
2008	0	3.8%	1534000	0.33	48%		0.000	974000	675000	90%	1688000
2009	0	3.9%	1594000	0.32	45%		0.000	927000	680000	95%	1701000
2010	0	4.0%	1658000	0.31	42%		0.000	803000	685000	100%	1713000
2011	0	3.9%	1723000	0.30	39%		0.000	847000	689000	100%	1723000
2012	0	3.8%	1788000	0.29	37%		0.000	823000	691000	100%	1729000
2013	0	3.7%	1854000	0.28	34%		0.000	786000	692000	100%	1731000
2014	0	3.6%	1921000	0.27	32%		0.000	763000	691000	100%	1729000
2015	0	3.5%	1988000	0.26	30%		0.000	738000	689000	100%	1723000
2016	0	3.4%	2056000	0.25	29%		0.000	724000	685000	100%	1713000
2017	0	3.3%	2124000	0.25	28%		0.000	737000	708000	100%	1770000
2018	0	3.3%	2194000	0.25	27%		0.000	751000	731000	100%	1828000
2019	0	3.3%	2266000	0.25	26%		0.000	765000	755000	100%	1889000
2020	0	3.3%	2341000	0.25	25%		0.000	780000	780000	100%	1951000

Water supply Analysis is based on the following data:
Unicef Assessment Report 2003
USAID Daily Report
Information from Amanat
24 hrs power supply

*Based on UFW 25% column 6

RTI/LGT Nov. 2004

COST EFFICIENT WATER FEE PER HOUSEHOLD covering O&M cost caculated by usaids report dated nov-2004

Conditions:

330 liter per capita/day
Household 10 capita
Industrial and Commercial User pay for their own water demand calculated with 40 l/c/d
Government pays for itsown water demand calculated calculated with 55 l/c/d
Rate at 100% collection of bills
Fee does not include any investment

	Unit	Cost p Unit	Quantities	For 5,5 mio population daily production 3.048.000 m³/day w/out loss $/day	Per Household per month without loss	Per Household per month with 25% loss if 330 l/c/d are supplied	Per Household per month with 50% loss if 330 l/c/d are supplied	Per Household per month with 70% loss if 330 l/c/d are supplied
Power	0,4 Kwh/m³	0,035 $/Kwh		106.680	← 167			
Al2SO4	30 ppm	100 $/ton	40,95 ton/day	4.095				
Cl2 (gas)	5 ppm	450 $/ton	6,825 ton/day	3.070				
Employees	Nr. 5.500	200:26 $/d		2.300				
Administration	%	2%		1.000				
Repair Netw.	Lump sum	60 $/m	1062 meter/day	63.720				
Maintenance	Estimation	10.000 $/d		10.000				
Transport	Estimation	1.000 $/d		1.000				
Managers	Nr. 26	1.000:26 $/d		1.000				
Total				232.865	7,524 $	10,03 $	15,05 $	25,08 $

232.865 $: 3.048.000 m³ = 0,076 $/m³

Per household: 0,076 $/m³ x 0,33 m³ x 10 capita x 30 days = 7,524 $ per Household without loss

Shows how much consumers have to pay for a bad maintained and deteriorated network

18-Water distribution system:-

18.1 Introduction:-

Treated water for the city is produced in many existing treatment plants, Karkh works located about 30Km. north of the city was completed 1989 of capacity 1280 Mld supply mainly Karkh side and part of its water supply Rasafa across Muthana bridge, Karkh side also supplied with water from three small capacity old treatment plants abstract water from Tigris river within the city boundary total available capacity of these three plants 420 Mld.

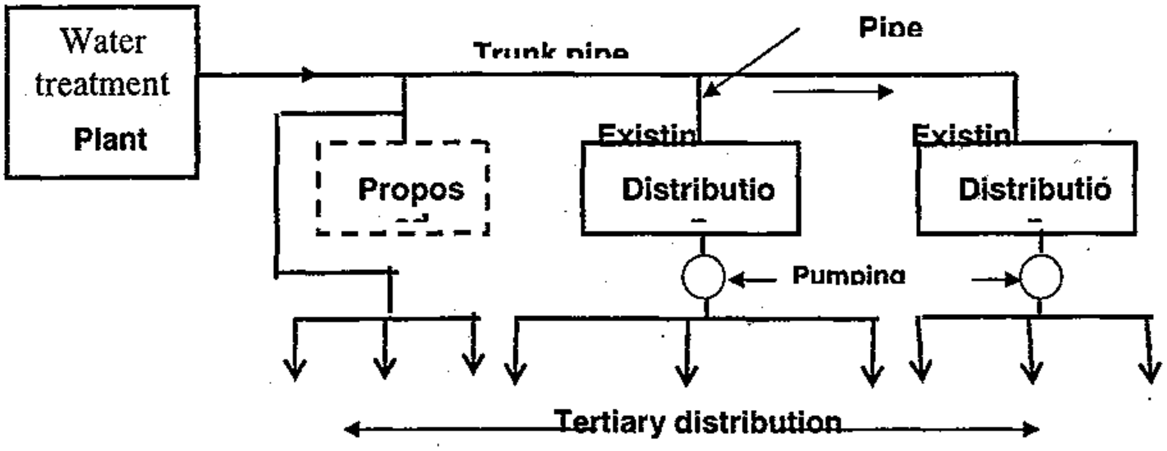
Rasafa side of the city is supplied recently with the water produced by 7-Nissan treatment pant of available capacity of 505 Mld located at the north boundary of Rasafa, and also receiving water from Karkh from four small & old treatment plants of total capacity of 164 Mld, abstracting water from the Tigris within the city. And there also a number of compact unites distributed within the area of total capacity 100 Mld.

The treated water before completion of Karkh treatment plant used to be distributed to the city area, in both sides, by pumping directly into the distribution network on which a number of stand pipes (high level tanks) were installed to store water during low consumption hours and supplement the flow in the distribution network during high demand hours.

When the large capacity Karkh treatment work planned to be implemented, the system of water distribution in the city was changed in principle to better one to satisfy the changes in city planning and urbanization and to suit the expanded area of the city.

the integration study of water requirements of the city of Baghdad to year 2000 (final report 1984) established a system by which the treated water is transported from the new treatment plants via transmission pipe lines from which water is supplied to service reservoirs located at selected sites. Each of these reservoirs equipped with pumping station capable to pump the stored water to a limited area of the city called (distribution zone). Each zone has its own water distribution network to distribute water to the consumers in that zone.

The system adopted for the water distribution to various zones in the city of Baghdad composed of trunk network, pipe junctions, distribution reservoirs and tertiary distribution network.



18.2 Distribution zones:-

The system of water distribution adopted for the city of Baghdad is based on subdividing the area of the city into distribution zones as shown in figure (5-1) of reasonable area and population each is served with a distribution reservoir of predetermined capacity , such capacity is calculated to equalize the fluctuated demand rate of water by the consumers of the zone over 24 – hours , plus the fire fighting demand and a storage for emergency reserve in case supply to the reservoir is reduced or ceased temporarily for any reason .

At each distribution reservoir the water from the storage tank is pumped through a number of pumping sets of variable capacities (or pumping sets of variable speed) into the zone distribution network (tertiary distribution network) to meet the variable hourly demand for water within the area or zone ,such a variable supply by the pumping station can be automatically controlled through the water pressure in the network of the zone which have to be maintained between two preset water heads (max. and min.).

By this system we permit uniform continuous treatment rate of treatment plants and uniform pumping rates of water into the transmission pipe system which supply the distribution reservoirs with water at uniform rate of flow to store it in advance of actual needs at different locations.

The advantages of storage distribution reservoir:-

1- The demands on source, treatment, transmission and distribution trunks uniform and equal.
2- Reducing needed sizes and capacities of most components of water system.
3- The system flow pressures are stabilized through out the service area.
4- Reserve supplies are available for contingenc

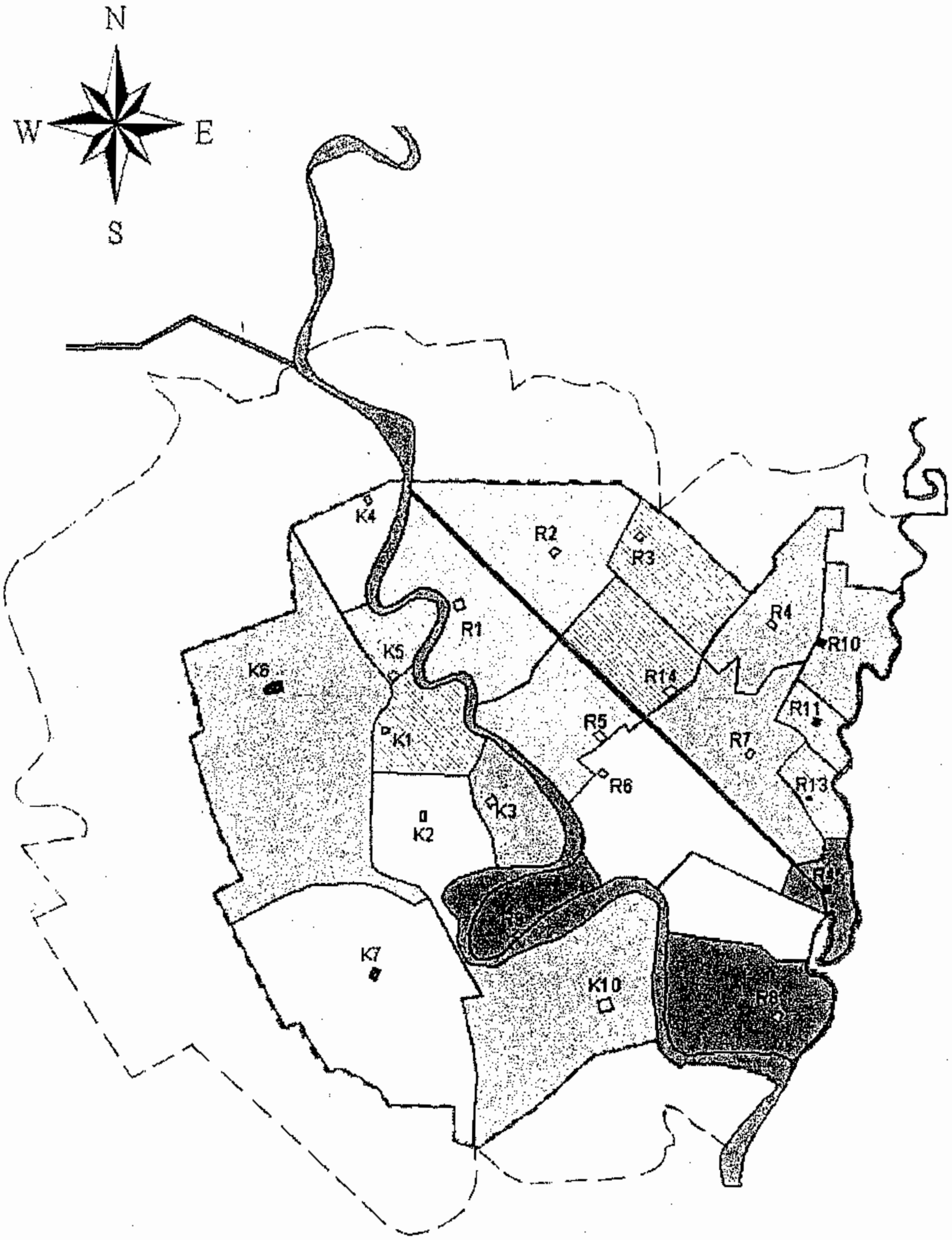


Figure (5 - 1) Water Distribution Zones

18.3 Distribution zone water requirements:-

The water requirement in any distribution zone depends on two main factors, the recent population and predicted future population of the zone and the water allocation rate per capita in the zone based on field study categorizing the pattern of average water use per capita of the population of each zone.

The zones vary from point of view of the degree of urban development and saturation in built houses which can be classified as completely developed or developing zones.

In developing areas the water demand growth is due to a combination of population increase and increase in consumption resulting in a high overall rate of growth in water requirement for these areas. Another important factor which could affect the variation in water consumption in different areas is the type of housing and social and living standard, besides the areas of house gardens and raw water availability.

Density of population in developed zone is a factor in evaluation of daily water demand rate, as in the low density zone people consume higher rates of water than in high density zones, due to a better standard of living and larger residential lots which requires more gardening water.

Studies previously carried out by Binnie and Partners and Sobea for pipeline and trunk pipe system in Baghdad city have subdivided Baghdad area into many distribution zones, almost each distribution zone will be served by a storage reservoir and pumping station and a tertiary water distribution network, named R1, R2, R3 . . ..etc. in Rasafa side and K1, K2, K3.... etc. in Karkh side, each is bounded to limit its area and numbers of mahala it includes.

Some of these distribution zones are already developed; others are developing and the remaining still to be developed by construction of residential and commercial buildings.

Actually these distribution zones are of different characteristics as to standard size of residential lots and as to standard of living of people of that zone and number of families living in each dwelling. Also these zones differ in respect of land use as industrial, commercial, green areas or open areas.

Analytical studies have been conducted using the available data of the record of 1997 census, of which the population and population density of the different zones were estimated, knowing the undeveloped area of each distribution zone and the anticipated growth in development, then population for cast of each zone can be estimated.

Average water requirement per capita per day in each zone differ according to the standard of living and dwelling lot size and type of resident construction and other water requirements (as garden water and water for air cooling system) were also estimated for each zone based on the result of a research study (Al-Samaria 1994)

for water consumption pattern in various districts of the city of Baghdad, Where seven categories of residential areas concerning domestic water consumption (annual average) were specified.
By regrouping the seven categories into three categories (A, B&C) of specified average water consumption (domestic) and adding to it estimates of other uses (commercial, industrial, governmental and loss), the gross average water demand per capita per day is estimated for each category. The average daily demand per capita for categories A, B, C are 700, 550& 450 lpcd respectively.
The water required by each zone as peak day demand is estimated by using peak day factor of (1.4) related to the average day demand.
The peak day demand of the zone is used to determine the size of the pipe feeding the service reservoir with water, which in it's turn will supply the specified zone with its share of water according to its demand during the hours of the day, such hourly demand varies during the 24, hour as to day activities of the people, the peak hourly demand per capita in each zone is estimated as 1.6* peak daily demand of that category.
The growth demand for water in the distribution zones are estimated at the specified years of the period up to year 2027, the growth in demand is due mainly to changes in zone area population and urban development anticipated during the period.
The daily water demand (P.D.D) as Mld for each distribution zone and the total for Karkh and Rasafa sides are shown in table (5-1).

18.4 Service storage reservoirs (distribution reservoir):-

Hydraulically is an integral part of the water supply distribution system. Trunk pipe to supply the reservoir at a rate sufficiently high to meet the 24-hour demand of the maximum day demand, hourly demands in excess of this rat are supplied from storage to this must be added the water reserve needed in a series of conflagrations.

Further volumes of water must be stored to allow for the further interruption of supply, for repairs of conduits or other works and during reduced flow or close up of supply for short periods. The three major components of service storage are:

Equalizing or operating storage.

Fire fighting reserve.

Emergency reserve (contingencies)

18.4.1 Equalizing or operating storage:

If the planned rate of supply and the fluctuation in the rate of consumption (demand) during 24-hours are known, the equalizing storage can be estimated from a rate curve or from a mass diagram similar to Rippls diagram.

For the city of Baghdad study data based on actual hourly consumption during one day were collected and a rate curve have been established as mentioned in article (4.5)figure (4-1). A diagram for the accumulative water consumed showed that the equalizing storage amount to 15-22% of the average day's consumption. At average day's consumption of 500 lpcd the equalizing storage per capita is 110 lpc, this represent a duration period of 5-hours and about 20% of the day consumption.

18.4.2 Fire demand:-

For single family and two family residential areas (not exceeding two story in height, the required fire flow for single fire varies from (30-760) l/s and not exceed 380 l/s for incombustible or fire resistive buildings.

Fire flow and duration criteria set by insurance service office 1974 (USA) , specify that where distance between dwelling units less than three meters, flow required (95-125) l/s and for continuous buildings 160 l/s, the flow duration for these (3-2) hours.

Using a fire flow of 150 l/s and duration of 3 hours give fire demand storage of 1620 m^3.

18.4.3 Emergency Reserve:-

This reserve is to supply water to the zone for a period needed to make repairs or for a period during which supply to the reservoir is ceased or reduced due to other reasons. There is no standard or criteria as to the storage for emergency, it is some times taken as equal to the 25% of the total storage capacity or it my be estimated equal to 8-hr pumping period.

18.4.4 Total storage:-

Total storage is estimated as the sum of the components requirements. It depends on economic considerations (supply lines against storage cost).

One of the methods to estimate the total storage of a distribution reservoir is to take it as equivalent to an eight hours pumping period based on peak demand plus fire reserve. As fire reserve is usually based on fixed flow rate for certain duration period (i.e. fixed quantity) and usually amount to low percentage of total storage, and the equalizing storage amount to 15-20% of the average day's demand (4-5 hours pumping period).

It would be reasonable to estimate the total storage capacity as equal to 10 hr-pumping period based on peak day demand of the zone served by the service reservoir, or 1.4× 10 hours pumping period based on average day demand.

18.4.5 Estimate of the capacity of distribution reservoir:-

The area of the city of Baghdad was subdivided into distribution zones by the consulting engineers Binnie & Partners and Sobea, on that subdivision, the main pipes network in both sides of the city were designed, and most of it was already implemented and even the sites of many of the reservoirs were located and few number of them were already constructed. The capacity of storage for each reservoir was previously estimated by the consultants according to a growth rate up to year 2000.

In the recent integration study for water demand up to the target year 2027, the storage of each reservoir will be estimated according to the population growth and anticipated development in each zone taking into considerations the special conditions of some zone as to their large areas and the possibility of splitting into more than one zone or increasing the capacity of existing reservoirs.

18.7 Existing Reservoirs:-

As mentioned before, in the integration study of Binnie and partners dated 1982 and final report 1984 it was recommended to build 14 reservoirs in Rasafa + 10 on Karkh bank, the estimated capacity of each reservoir was indicated up to year 2000. Most of the proposed reservoirs still not constructed, but were substituted by temporary by passes where the distribution networks directly connected to the trunk system.

- In Rasafa side: **four reservoirs located in Baghdad East (R10, R11, R13 and R45) have been built before 1990, these four reservoirs are not connected to the trunk system laid by Sobea, R10, R11 and R13 are fed with water by the distribution system itself and R45 is fed through a pipe line from the old system. The four reservoirs are of a similar design the capacity of each 17.5 Ml and each is rated for a 65 Mld design flow. The zone 45, in which R45 exist, not developed yet, so R 45 used to pump directly to distribution system of zone (R12) since it was constructed.**

The reservoirs R10, R11, R13 were constructed for a storage capacity of 17.5 Ml (estimated size for year 2000), the size of these reservoirs should be enlarged to meet the required demand in future as shown in table (5-1).

- In Karkh side: **four large reservoirs have been built at the same period of Karkh treatment plant construction i.e. before 1988, they are:**

- Taji Reservoir: **which include two tanks of total capacity of 28Ml; it is directly connected to the pipes transmitting water from Karkh treatment plant to Baghdad. This tank serves Taji municipality north of Baghdad.**
- Karkh North Reservoir: **include two tanks of total volume 225Ml it is fed directly by water from Karkh treatment plant through two transmitting pipe lines 2100mm and 2300mm , this reservoir supply Abu Graib reservoir through two pipes 1400mm and also it supply South reservoir through two pipes 1400mm and 1600mm diameter.**

  Six pipelines of 1400mm diameter are connected to the Karkh North distribution network.

  Links also provided between inner Karkh system and distribution network of zone K6 which allow Karkh treatment plant water to supplement water produced by Karama and Qadsiyah.

  At the Karkh North reservoir there is enough space for other two additional pumps and a land area for future extension.
- Karkh South Reservoir: **this reservoir of capacity of 180 Ml is supplied with water from Karkh North reservoir through two supply pipelines 1400mm and 1600mm, it boosts water to the distribution network of Karkh South area (zone K7).**

19 . Unit Cost of Implementation for Treatment Plant:

As a case study for unit cost implementation we take RASAFA WTP which its total capacity is 2,275,000 M^3/day (tow million tow thousand seventy five) Cubic meters per day. This project contains of the fallowing mucher components:

1. Intake structure
2. Treatment Plant
3. 16 Earth Reservoir
4. Transmission Pipes
5. distribution Pipes

Table (1) show the total cost for the project while table (2) show the estimated cost for construct the 16 earth reservoir and table (3) show the WBS estimated cost for reservoir R3.From these table we can make the fallowing calculation:

- **For Intake and treatment plant:**

Total Estimated Cost is (700,000,000 US$ Seven Hundred million US$)

Total Production Capacity (2,275,000 m3/day)

So the Estimated unit cost will be:

700,000,000 / 2,275,000 =**3,077 US $/m3/day (Tree thousand and seventy seven US$ for every cubic meter per day)**

- **For Erath Reservoir (we take R3)**

Total Estimated Cost is (71,164,008 US $)

Total Capacity is (13,000 M^3 Thirteen Thousand cubic meters)

So the Estimated unit cost will be:

71,164,008 /13,000 = **5,474 US$ (five thousand four hundred seventy for USD)**

Table (1)

Estimated costs for Rusafa WTP		
Item	Description	Estimated Cost(million US$)
1	Consultant Services	20
2	Intake and Treatment Plant	700
3	Earth Reservoir	1200
4	Transmit ion & Distributions Pipes	400
5	Electrical Connection	30
6	Land usage	20
	Total	2370

Table (2)

SCHEDULES OF PRICE

Summary of Schedules

		Lump sum price US$
11.1	Reservoir Works R1	53,258,756
11.2	Reservoir Works R2	63,333,643
11.3	Reservoir Works R3	71,164,008
11.4	Reservoir Works R4	45,270,149
11.5	Reservoir Works R5	55,332,849
11.6	Reservoir Works R6	68,697,651
11.7	Reservoir Works R7	73,436,477
11.8	Reservoir Works R8	79,611,880
11.9	Reservoir Works R9	34,601,523
11.10	Reservoir Works R14	67,492,821
11.11	Reservoir Works K1	41,248,670
11.12	Reservoir Works K2	46,563,521
11.13	Reservoir Works K3	40,752,786
11.14	Reservoir Works K4	36,888,070
11.15	Reservoir Works K5	29,703,003
	TOTAL ESTIMATED PRICE US $	807,355,808

Table (3)

RESERVOIR WORKS R3

Item No	Brief description	Lump sum price
	(I) Civil works	
3.1	site works	3,118,269
3.2	Roads and paving	785,730
3.3	Reservoir with inlet and outlet	
	valve chambers :	
	(a) piling	16,437,587
	(b) structures	24,681,855
	(c) finishes, fixtures and fittings	347,566
	(d) Pipe work	32,241
3.4	Pumping Station	
	(a) piling	870,421
	(b) structures	2,780,359
	(c) finishes, fixtures and fittings	730,250
3.5	Generating station with cable	
	Channels	
	(a) piling	234,346
	(b) structures	772,530
	(c) finishes, fixtures and fittings	386,922
3.6	Chlorinating station	
	(a) piling	234,346
	(b) structures	624,918
	(c) finishes, fixtures and fittings	342,613
3.7	Fuel Storage	
	(a) piling	80,665
	(b) structures	288,875
	(c) finishes, fixtures and fittings	13,801
3.8	Valves and chambers	520,281
3.9	Site pipe work	674,556
3.1	Guardhouse	44,458
3.11	Landscaping	671,075
	Total civil works	54,673,664

Schedule 11.3 (Contd)

Item No	Brief description	Lump sum price
	(ii) Plant	
3.12	Pump sets	1,791,534
3.13	Pumping station pipe woks	1,931,279
3.14	General mechanical works	245,236
3.15	Electrical distribution system	1,384,099
3.16	Standby power generation	1,950,416
3.17	Building services	1,811,670
3.18	Supervisory equipment	405,425
3.19	Telephone equipment	33,059
3.20	Chlorination equipment	617,169
	Total plant	10,169,887

(iii) Reservoir overflow

3.21	Pipeline : 200 mm diameter	3,326,400
	(approx.) 1680m x ii)60p (rate/m)	
3.22	Major obstacles	462,132
3.23	Control Chamber	518,047
3.24	Outfall	1,486,393
	Total reservoir overflow	5,792,972

Schedule 11.3 (Contd)

Item No	Brief description	Lump sum price
	(v) Miscellaneous	
3.25	Training Employer's personnel	25,126
3.26	Instruction manuals and record	70,594
	Drawings	
3.27	Spare parts and tools (Note 1)	333,511
3.28	Spare pipes and valves (Note 2)	3,379
3.29	Extended Maintenance	94,875
	Total miscellaneous	527,485

Total Schedule 11.3 RESERVOIR WORKS R3	71,164,008

20. Unit Cost of Implementation for Pipe Work:

Table (1) Show the Estimated unit cost for UPVC Pipe line, while table (2) show the estimated unite cost for ductile pipe line.

Table (1)

Unit Price for UPVC Pipe line				
No	Dim(mm)	Laying cost (ID/LM)	Providing Cost (ID/LM)	Provide & Laying Cost (ID/LM)
1	110	11000	6000	17000
2	160	14750	8250	23000
3	225	19850	23750	43600

Table (2)

Unit Price for Ductile Pipe line				
No	Dim(mm)	Laying cost (ID/LM)	Providing Cost (ID/LM)	Provide & Laying Cost (ID/LM)
1	100	17000	43000	60000
2	150	18000	62000	80000

この報告書は、水道計画の研修生が、忙しい業務の中で、ある時は自宅で、ある時は、夜中に、大いなる努力によって作成したものである。作成手順も作成された内容も非常に優れており、立派な報告書となった。ここに記して研修生に感謝したい。「皆様、ありがとうございました」。次は日本でお会いしましょう。

JICA水道専門家　岩崎皓一

The present report is prepared by the extensive effort of BWA trainees for policy and development planning of water supply. The report is excellent in technical approaches and in outcomes as well, and so, the expert says "Thank you very much for your great effort" and hopes conditions of Baghdad water supply improved according to the plan described therein. Hope to see you again in Japan next time.

JICA Expert on Water Supply

Koichi IWASAKI